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Battelle Technical Review

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Xerography—From Fable to Fact

INVESTIGATOR OF GASES IN METALS

MANLEY W. MALLETT

Detecting traces of gases in metals as infinitesimal as one part in 10 million requires patient work and meticulous attention to detail. Though difficult, such research is neither spectacular nor popular.

For Manley W. Mallett, however, the investigation of gas-metal relationships is an absorbing interest. His painstaking work and inventiveness in developing unique apparatus and methods of handling problems have enabled Manley to make outstanding contributions in his field. His studies have included the determination of gases in metals, the kinetics of gas-metal reactions, the rates of diffusion of gases in metals, and the determination of the solubility of gases in metals.

Manley graduated from Toledo University with a degree in chemistry. In 1938, he joined the Bureau of Standards where he helped develop a method of preparing crucibles by slipcasting which was useful in early AEC work. When he came to Battelle in 1940, his first project was the development of special vacuum-fusion apparatus.

Since his first project, Manley has had a leading part in a number of significant developments. He was corecipient of the Lincoln Gold Metal Award for the discovery of the key role of hydrogen in the cracking of armor plate weldments and the subsequent development of low-hydrogen welding electrodes. His identification of uranium sesquicarbide added considerably to the understanding of the uranium-carbon system. Manley's work led to the development of new analytical procedures for determining hydrogen in such light metals as lithium and aluminum. He also contributed much to the improvement of methods for determining oxygen in molybdenum and titanium.

Manley has been prolific as an author. In addition to the more than two-score articles of which he has been author and coauthor, he has written, of course, many reports based upon his researches. In the past few months, he has coauthored four papers recently presented before the Electrochemical Society. Two others have just been presented at the National Metal Congress before the American Society for Metals.

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"USE" Research in Modern Competition

ONE OF THE BEST ways for a materials producing company to grow and prosper is to maintain a constant program of research aimed at finding new uses for its products. One needs but enumerate some of the most successful corporations today to realize how true this is. The "big names" in the materials field are invariably companies that have continually sought new uses for the goods they produce. Even many of the large corporations in the fabricating field owe much of their growth to finding new applications for their products, although here the extension of markets through the lowering of production costs is frequently the dominating growth factor.

"Use" research has been particularly effective in enabling the plastics, glass, petroleum, steel, and aluminum industries to reach their present positions in our economy. The many plastics products of utility and beauty now on the market came from deliberate exploratory investigations to find uses for such materials. Glass, without "use" research, would still be primarily windowpane material. But, because of the foresight of the glass industry, this material now has many additional uses, such as a structural, insulation, and textile material. Petroleum, not satisfied with gasoline and lubricant markets alone, has created tremendous markets in the heating and synthetic chemistry fields. Steel and aluminum have extended their uses into hundreds of new areas, taking over functions previously held by other materials and creating many new products.

In times of great demand for materials, such as in recent years, there is a tendency for producers to neglect "use" research and devote all their efforts to production research. As much as production research is needed, to concentrate upon it at the expense of "use" research is a dangerous practice. During periods of high demand for any particular material, industrial consumers are most likely to be concentrating their efforts on "conservation" research—trying to find ways to reduce the amount of the material in their products or to find substitutes. If the consumer's conservation and substitution research is successful, a market may be reduced or lost. Unless this loss is counterbalanced by new uses for the material developed through the producer's "use" research, the material may lose its economic importance.

The goal, then, of any company in the materials field should be to make its "use" research more effective than its customers' conservation and substitution research. This is a realistic way to meet competition and to achieve continuing growth.

Sometimes companies faced with competition and shrinking markets see the hazards ahead of them, but fail to see the opportunities. Preoccupied with how to hold slipping markets, they neglect chances to develop their materials to meet the needs of new markets. With technology so complex, it is easy to overlook developments in remote and unfamiliar fields that might lead to new product outlets. A vigorously prosecuted and continuous program of "use" research, however, will ferret out the opportunities and keep the company in position to exploit them.

In this respect, the large central laboratories of industries and research institutes can be very helpful. Working in many phases of science these laboratories frequently foresee potentialities for materials while they are still obscured to producers.

Clyde Williams

President, Battelle Memorial Institute

Xerography---From Fable to Fact

by WILLIAM T. REID

The author is one of those men who possess an intense scientific curiosity. That curiosity, combined with real technical ability, has led him into widely varied fields during his twenty-four years in research. In more recent years, Reid has devoted his professional attention primarily to graphic arts technology. Chief of Battelle's graphic arts research division, he represented Battelle at the Second International Conference of Printing Research Institutes, at Stockholm, Sweden, earlier this year.

RADICALLY NEW DEVELOPMENTS in the graphic arts have been few and far between. Man's attempts to improve communication with his fellows led to the basic invention of printing, making possible for the first time the spread of information quickly and cheaply to large groups of people. For the first time, mass education became possible. No longer was there a limitation based on laborious copying by hand of old manuscripts so that a privileged few could have precious books to study and master. With texts and printed matter more easily available, schools for the common man were founded and illiteracy decreased rapidly. Books, instead of being for the few, were available to the many; and man's knowledge increased accordingly. Today, the graphic arts industry is sixth largest dollarwise in this country. Printed matter is so inexpensive and common that few people realize that most of the developments making it possible have taken place in the past few hundred years.

Although the Chinese practiced printing as early as 868, and had a form of movable type in 1041, the Western world had no feasible large-scale printing process until Gutenberg printed his Bible in 1454. Generally, this is the accepted birth date of letterpress printing. In 1798, Senefelder invented stone lithography, which firmly established the basic principles on which all lithographic offset printing is based. In 1895, Klietsch discovered the principle of photogravure printing, completing the triumvirate of basic printing processes as we know them.

Now, a new method must be added, as different from letterpress, lithography, or gravure as they differ among themselves. This new process, called "xerography", was invented by Chester F. Carlson in 1938. It is based entirely on physical and electrical phenomena. In its commonest form xerography is a completely dry photographic process, utilizing a unique type of plate not destroyed by exposure to light. Hundreds of images can be made from a single plate. It is a direct process which produces positive-to-positive prints, but negative-to-positive prints can be made if desired. Another form of the process, known as "xeroprinting", uses a plate not sensitive to light, and from which printing has been done in the laboratory at web speeds as high as 1200 ft. per min. Because of its immediate commercial importance, xerography has been developed most intensively.

THE EVOLUTION OF XEROGRAPHY

Carlson, a physicist as well as a practicing patent attorney and member of the New York bar, conceived the basic principles of this new photocopying process while searching for quicker and easier methods of copying records. Experiments in his own home laboratory showed the principles to be sound, and led to his writing patent applications covering the process. The first of these patents was issued in 1940, followed by others in rapid succession.

Like many inventors, Carlson had difficulty in selling his ideas to business men. Unwilling to venture into such a radically new field, printers and others were slow to invest capital in a process about which they knew so little. But the Battelle Development Corporation, a wholly owned, nonprofit subsidiary of Battelle, saw in the process the elements of success. This Corporation entered into an agreement with Carlson in 1944 whereby Battelle undertook research and development on xerography in its own laboratories. By 1947, the results obtained were so spectacular that The Haloid Company of Rochester, New York, entered into a license arrangement to commercialize the process. Since then, government agencies, including the Signal Corps, the Air Force, the Ordnance Ammunition Center, and the Engineer Research and Development Laboratories have joined with Haloid and Battelle in research on different

phases of xerography. The rate of effort possible from such a wide sponsorship of research has resulted in outstanding advances in xerography during the past five years.

How Xerography Operates

Basically, xerography depends on: (1) the formation of an electrostatic image on an insulated photoconductive surface by exposure to light; (2) the development of this "latent" image by a finely divided powder; (3) the transfer of this powder image to a permanent support such as a sheet of paper; and (4) fixing the image to that sheet, as by moderate heating.

Although xerographic plates have been made from many photoconductive materials, vitreous selenium is the preferred material at present. In making xerographic plates, specially purified selenium is vacuum deposited under closely controlled conditions on metal plates, such as aluminum. Selenium films, properly prepared, have the unique property of high electrical resistance in the dark and relatively low electrical resistance when illuminated. Thus, a light image can produce electrical changes in a plate which can then be made to form visible images by development with a dry powder. Xerographic plates of high quality are now being made commercially on a large scale.

Xerographic plates are sensitized by charging their surface to a potential of several hundred volts by spraying them with ions formed by a corona discharge. Although the voltage necessary to produce this corona discharge is high, the current is low and no danger exists to the operator. Several techniques have been devised to control the voltage accepted by the plate. Because of the high specific dark resistance of the selenium film on the plate, about 10^{15} ohm-cm., the potential on the plate leaks off only slowly in the dark. Thus the plates can stand and be used many hours after sensitization if necessary. Normally, plates are sensitized immediately before use.

Exposure of the sensitized plate is done by conventional methods, either by contact or in a camera. Usually a camera is preferred because it permits reproduction of material printed on both sides and permits making the copy either larger or smaller than the original. Exposures are short. The photographic speed of the commercial plate is about ASA 2, or approximately the same as process film with tungsten illumination. During exposure, the uniform charge on the surface of the plate leaks through the photoconductive selenium film in the illuminated areas. The dark areas of the image, the unexposed areas of the plate, retain their charge, thereby producing a latent electrostatic image.

This electrostatic image is developed by a finely divided powder, either poured over the surface of the plate or applied to the plate in the form of a cloud. The particles of powder must carry an electrostatic charge of polarity opposite from the surface of the plate for the powder to be attracted to the image areas. To provide this charge for bulk powders over the surface of the plate, known as cascade development, the powders are mixed with a granular material. This carrier material is so chosen that triboelectric, or surface electrification, effects produce the proper electrical charge on the powder when the two are separated. Thus, when the carrier-powder mixture is cascaded over the plate, the powder leaves the carrier with an electrical charge that causes it to stick to the plate only where some voltage still exists. Because this is where no light reached the senstitized plate, the image formed is a direct reproduction of the original.

Powder-cloud development is similar, except that the fine particles of powder are air-borne, the cloud passing over the surface of the exposed plate. Special techniques are used to impart the correct polarity to the powder particles so that they will be attracted to the image areas of the plate.

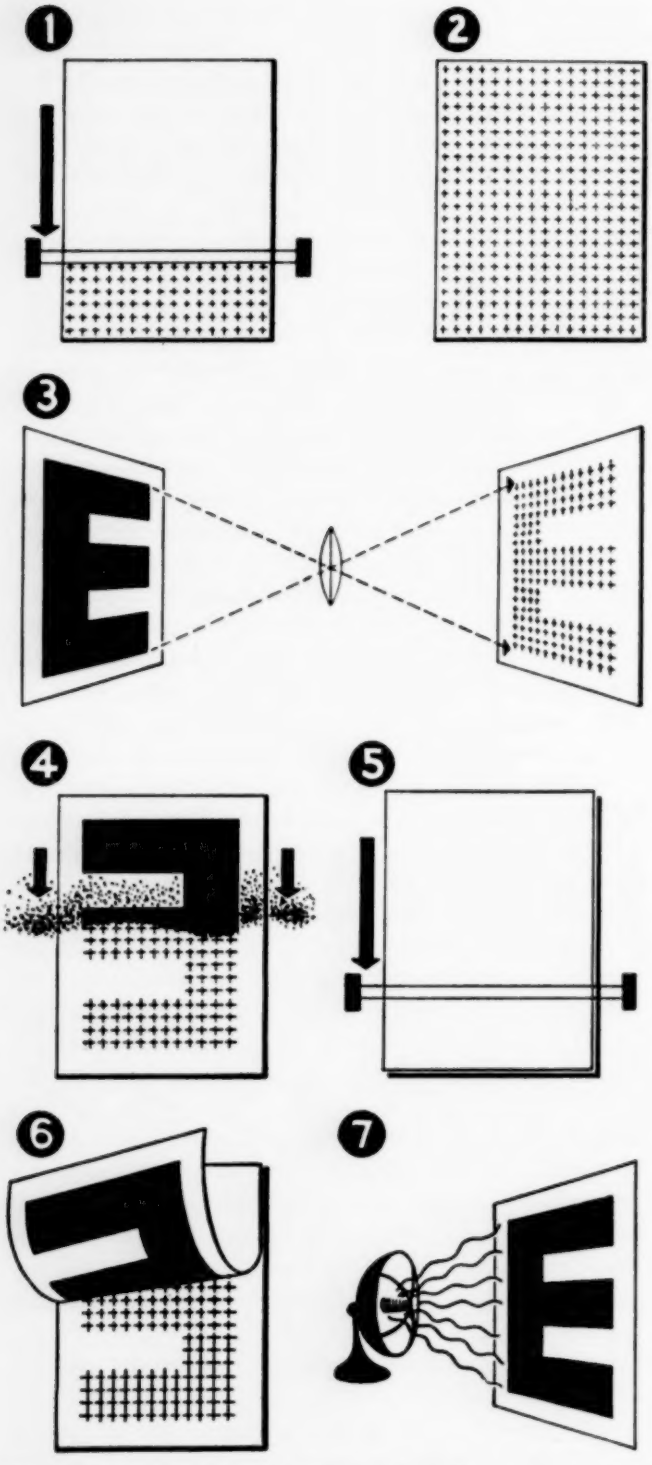
To use the image developed by either of these methods, it must be transferred to a permanent support, such as a sheet of paper. The operation is simple; a sheet of paper is laid on the developed xerographic plate and an electrostatic field is formed by the same device used to charge the xerographic

MEDAL FOR XEROGRAPHY INVENTOR

Chester F. Carlson, inventor of xerography, received the Franklin Institute's Edward Longstreth Medal on October 21. This Silver Medal, first awarded in 1890, is given for inventions of high order and for particularly meritorious improvements and developments in machines and mechanical processes. Carlson's citation reads as follows:

"For his effective combination of known principles of optics, photoconductivity and electrostatics into a workable process for producing facsimiles of written matter, drawings and other documents by a system that is rapid, dry, permanent and also capable of placing a reproducible image on an offset paper master."

Carlson first brought his invention to Battelle for development in 1944.



The important steps in the xerographic process are: (1) The surface of the specially coated metal plate is electrically charged. (2) The entire plate coating is positively charged. (3) The copy is projected through the lens in the camera. The plus marks show the projected image with positive charges. Charges disappear in areas exposed to light. (4) Negatively charged powder is applied, adhering to the positively charged image. (5) After powder treatment, a sheet of paper is placed over the plate and receives a positive charge. (6) The positively charged paper attracts the powder from the plate, forming a positive image. (7) The print is then heated to fuse the powder and form a permanent image.

plate initially. This causes a large part of the powder, which forms the image on the plate, to move to the paper. The paper is then stripped off. The characteristics of suitable paper are not critical. More than a hundred different types of paper have been used successfully to accept the powder image. If desired, the image can be transferred from the paper to wood, metal, glass, plastics, or other solid materials. Flexible materials such as cloth can accept the image directly from the xerographic plate.

Because the image at this stage is held only loosely to the permanent support, it must be "fixed" to prevent smudging. Fixing generally is done by heating the image, because the powder is compounded with a thermoplastic resin that fuses and therefore bonds firmly to the supporting surface. Other methods used successfully include partially dissolving the image by vapors of suitable solvent, using a pressure-sensitive surface to receive the image, or precoating the paper with a material that will hold the image permanently when heated.

Finally, because some powder is not transferred from the plate to the paper, the plate must be cleaned before it can be resensitized to receive another image. Usually, this is done by cascading a powdered material over the plate that scrubs the remaining powder from the surface. Rotating fur brushes also clean the plate excellently.

Commercial Equipment for Xerography

The first commercial equipment for xerography was placed on the market by Haloid in 1949. This equipment, trademarked "XeroX", consisted of the XeroX Copier, Model A. It could make single contact copies of letters, line drawings, office forms and similar originals whose size did not exceed 8½ inches by 13 inches. The sensitizing unit and trays for developing the image and for cleaning the plate were built into the Copier. A separate thermostatically controlled XeroX Fuser also was supplied to heat the final image to fix it permanently to the paper support. The contact exposure part of this unit is now obsolete and is not regularly furnished by Haloid.

In 1951, Haloid supplemented this unit with the XeroX Camera No. 1, which permits copying material with text or images on both sides. This camera has a fixed-focus wide-angle lens giving copies the same size as the originals, up to 8½ inches by 13 inches. It is intended to be used with the charging device and the developing and cleaning trays of the XeroX Copier, Model A.

By 1952, the need had developed for a more flexible camera, leading to the provision by Haloid of the XeroX Camera No. 3. Essentially a small-scale process

camera, this unit permits variable-size copying of originals as large as 17 inches by 22 inches. Focusing scales are provided to allow accurate reduction to one-half or enlargement of two times. Equipped with an automatic timer and a built-in lighting system, it provides XeroX users with a flexible and handy unit for copying a wide variety of subjects.

In 1953, the XeroX Lith-Master Camera No. 4 was produced. It is similar to the No. 3 Camera except for an improved lighting system, an easel attachment for copying record cards in panels, and relays for synchronizing the lights with the shutter and for controlling the fuser so as to balance the electrical load.

With the latest camera, Haloid also announced the availability of the XeroX Lith-Master Processor, Model X. The photograph shows this Processor with a Fuser and Camera No. 1. This processor replaces the early Copier which previously had provided the only standardized equipment for sensitizing, developing, transferring, and cleaning. More convenient to use than the Copier, the Model X Processor also provides a compartment for storing paper, with a pull-button to eject one sheet at a time. A plate dispenser at the top holds six XeroX plates, feeding them one at a time to the operator in sequence, insuring proper rotation of the plates for maximum plate life. A further advantage of the Model X Processor is that the developing system has been modified to develop solid areas and halftones, not possible with the earlier equipment.

Special Xerographic Equipment

At the request of large consumers, Haloid has engineered special xerographic installations to meet specific requirements. One of the first of these was an installation in 1950 to produce a listing of license registrations of Michigan automobiles for state law enforcement agencies. Cards containing original automobile license applications were shingled on a unique copy board. A special xerographic camera photographed the cards, and the xerographic image was transferred to paper offset masters from which a conventional offset lithographic press produced the needed number of copies. Xerography thus produced facsimiles of the original license cards and eliminated any errors resulting from copying. At the same time,

This is Haloid Lith-Master equipment for use in making offset master plates. Included are the fuser, processor, and camera. This equipment performs all of the steps shown in the previous illustration.

the license book was produced six months sooner than would have been possible by methods used up to that time. In earlier years, a staff of 40 people worked from March until November to produce the book; a staff of 8 people using xerography completed it by May 1. Furthermore, xerography lessened the cost still more because more names could be listed on each sheet. This saved one-fourth of the cost of paper and lessened the bulk of the final book.

Another early special installation of xerography was in the plant of a large automobile manufacturer. Here, xerography was used to reproduce large numbers of engineering drawings, parts lists, trim sheets, and similar material. The xerographic camera was built into a wall of a darkroom, so that the operator could handle the sensitized and the exposed plates more easily. The crew consisted of one man to place original material on the copy board; one man in the camera room to sensitize, expose, and develop the plates; one man to transfer and fuse the images; and a fourth man to clean the plates. In a single day, this group could prepare 450 offset lithographic plates ready for the press. The equipment takes drawings as large as 24 inches by 36 inches and reduces them to the special xerographic plate size of 12 inches by 18 inches. Alternatively it enlarges originals as small as 6 inches by 9 inches to the xerographic plate size. One hundred paper copies and four vellums are made of each drawing more economically than by any other process, according to this user.

Uses of Xerography

Originally conceived as a means of making single copies of letters and other information for record purposes, xerography now is being used mainly to produce paper offset lithographic master plates. The process is identical with that for making single copies, except that the image on the xerographic plate is transferred to a specially prepared offset master plate rather than to a plain piece of paper. These offset plates are capable of producing large numbers of copies quickly and cheaply on small lithographic presses. Other methods of making lithographic offset plates for office duplicators, which involve photographic copying, cost from $2 to $4 for each plate, and require from an hour to a day to obtain. By xerography, the total cost in most installations is less than 40 cents for each plate, and the plate can be on the press turning out duplicates within three minutes of receiving the original copy. In addition, the master plate prepared by xerography is more durable than paper plates prepared by other methods; more than 10,000 prints can be prepared from the average xerographic master.

Many different applications have been found for xerographically made offset plates. These include production-order writing, instruction manuals, technical reports, office and factory forms of all kinds, long-distance telephone routing slips, Pullman diagrams, salesmen's lists, and hundreds of others.

Xerography also has been used to produce enlargements of microfilm. In its simplest form, an adapter fitted to a microfilm reader permits exposing a conventional Xerox plate in a few seconds, and processing in the usual way in a XeroX Processor. If desired, a negative-to-positive developer can be used, giving black-on-white prints. Automatic equipment for enlarging from microfilm on a big scale has been produced by Haloid on an experimental basis, but it is not on the market as yet.

The Future of Xerography

In the four years since the first commercial xerographic equipment was placed on the market, great advances have been made in improving the process, particularly in applying it to the making of offset masters. Other advances now being made in the Haloid and the Battelle laboratories will expand this field still further, and will open new fields of application. Work in other laboratories, under sublicenses granted by Haloid, is adding to the rapidly growing stature of xerography.

Continuous-tone xerography is expected to offer a dry photographic process comparing favorably in quality with conventional photographs, but with processing requiring only a few seconds.

Xeroradiography, now being converted from a laboratory development into the first few field-trial installations, is believed to be capable of revolutionizing the inspection of industrial welds, castings, assemblies, and other products which need nondestructive testing. Medical xeroradiography, also, has shown great promise.

High-speed copying of continuous-tone prints, the recording of light images no matter how produced, the production of metal offset plates by fast and cheap methods, all are promising future developments for this new reproduction method. Xeroprinting, too, can be expected to advance equally rapidly, once the demands are satisfied for research on xerography.

So, a new, basic reproduction method is available to supplement the three fundamental printing methods developed during the past 500 years. Although xerography is now but 15 years old, and has been commercially available only for the last 4 years, it is already a robust contender for a place in the printing world.

Promise of "Chemical Agriculture"

by Richard S. Davidson

Dr. Davidson assists in directing agricultural research at Battelle. Before joining the Institute in 1952, he served as plant pathologist in state experiment stations at Kingston, Rhode Island, Wooster, Ohio, and Auburn, Alabama. The author, who received his Ph.D. in plant pathology from the University of Minnesota, has written numerous articles on subjects in his field.

One of the most important developments in agriculture in recent decades has been the rapidly increasing use of chemicals. In the last twenty years, the production of agricultural chemicals (exclusive of fertilizer) has risen from 50 thousand tons to over 600 thousand tons. During the same period, the consumption of fertilizer has increased from 5 million tons to 22 million tons.

Such striking increases indicate that an old concept for improving the nation's agricultural productivity is receiving new life. That concept, becoming popularly known as "chemical agriculture", consists of putting greater emphasis on the science of soil fertility and plant protection. Over the next hundred years, the increasing application of the concept to farming technology may well exert as great an influence over agricultural output as the mechanization of farms has during the past century.

Benefits From Chemicals

The possibilities for the growth of "chemical agriculture" are tremendous. More than one billion acres of land are used for crop production in the United States. Only one-fourth of this acreage, however, is treated with fertilizer and one-eighth with pesticides. Fertilizer and pesticides might be applied economically to a large part of the untreated acreage. The results could be astounding. Insects, weeds, fungi, and other agricultural pests, for example, cause annual damages estimated at $13 billion. This is about 40 per cent of the value of total farm output in 1951.

The benefits from intensifying "chemical agriculture" are within our grasp because remarkable advances have been made by the chemical industry in developing specific chemical compounds to do specific jobs. Chemists are now concentrating on "building" organic compounds that promote plant growth or kill certain types of harmful insects, fungi, and weeds, without being harmful to humans, animals, or to desirable plant growth and development.

The celebrated insect killer, DDT, is still being used in large quantities, but other compounds are forging to the front. Methoxychlor is less toxic than DDT to warm-blooded animals. Benzene hexachloride (BHC) is being found more effective for killing the boll weevil, which for many years has plagued cotton crops. Because house flies build up considerable resistance to DDT, other apparently more suitable chemical derivatives, with a chlorinated hydrocarbon base, are being developed and marketed.

Within the past two years, more than 20 brands of soil conditioners for promoting better soil structure have been placed on the market. Also available are systemic insecticides that penetrate the plant system and provide built-in protection against attack from certain types of insects.

One company recently developed a chemical compound known as CDAA (α-cyano-β-(2,4-dichlorophenyl) acrylic acid). Studies have shown that this compound, applied at low concentrations, inhibits the growth of the main stem of tomato plants and delays the flowering of ornamental plants, without visible injury to other parts of the plants. CDAA joins a growing family of plant-growth regulators that may possibly hold the key for protecting budding plants against frost. Plant-growth regulators are already being used to prevent fruit drop before harvest time and the undesirable growth of potatoes and nursery stock during storage or shipment.

A recent report by a leading trade journal cites the increasing use of defoliant chemicals for cotton as one of the major developments in southern agriculture today. "These chemicals, by causing plants to drop their leaves before picking time, speed up the hand picking of cotton as much as 100 per cent. Without defoliants, the widespread use of mechanical cotton pickers in the South would be virtually impossible."

The same report describes the vastly increased use of 2,4-D and 2,4,5-T for the destruction of mesquite, a spiny, deep-rooted shrub that chokes out wanted vegetation on the cattle-grazing lands of the West. In years past, everything from fires to bulldozers has been used against mesquite with little success. During one recent year, however, 2,4-D and 2,4,5-T wiped out more than half a millon acres of this stubborn pest. These and other related herbicidal sprays do many other jobs, including the killing of harmful weeds in small-grain crops and sugar cane and the destruction of unwanted vegetation around homes, industrial sites, parking lots, railroad beds, waterways, and irrigation ditches.

New Agricultural Jobs For Chemicals

Present successes in the development of tailor-made agricultural chemicals suggest the possibilities of compounding new and improved ones. To cite a few examples, chemicals are needed (1) to enable plants to absorb considerably more of the sun's energy than the present 4 per cent; (2) to regulate the loss of moisture from foliage and thus cut down damages from drought; (3) to improve the nutritional quality of foods, in addition to simply increasing bulk yields; (4) to force soybeans and other crops to mature all fruits at the same time, thereby facilitating mechanical harvesting; and (5) to impart new qualities to plants such as stiff stems, deep roots, and a high percentage of usable parts.

The nation's population is increasing annually at the rate of 2 million persons. At the same time, usable acreage and the farm labor force are decreasing. A pressing need, therefore, exists for improving the quantity and quality of our agricultural output from presently worked units of land. Perhaps the greatest single opportunity for meeting this need is through an intensification of "chemical agriculture". The investment in research and time needed to bring chemical agriculture to maturity will be considerable. But there is every indication that huge dividends will accrue to the American economy from this investment in more efficient use of our existing agricultural resources.

Creative technology is today largely dependent for its achievements upon a hybrid, the scientist-engineer. Which talent of this dual personality comes first in title depends on whether the individual is at a given time oriented toward the "think" or the "thing".

Earl P. Stevenson
Arthur P. Little, Inc.

Notes From Battelle

SOFT X-RAY STERILIZATION

The effects of radiation on bacteria have been the subject of research since Roentgen discovered X-rays in 1895. The lethal effect of X-radiation on living matter has been known for many years. More recently, scientists have been interested in the practical applications of this knowledge in the sterilizing of materials and the preservation of foods.

Research has shown that both "hard" (above 150 kvp) and "soft" (below 150 kvp) X-rays have their uses in sterilizing materials. Radcliffe F. Robinson and Robert C. McMaster report that investigations at Battelle have indicated certain inherent advantages of soft X-rays in this field.

To begin with, the cost of production is much lower for soft than for hard X-rays. Tubes in soft X-ray equipment have a much longer life. The low-voltage equipment is also simpler, more rugged, and more easily shielded. Because it is less bulky, soft X-ray equipment is easily installed and requires little space. It can be made nearly automatic. Finally, because of its simplicity, no specially trained X-ray operators or technicians are needed to run or repair it.

Estimates have been prepared on the cost of surface sterilization of foods by soft X-rays. For example, it would cost approximately $.0002 to sanitize the surface and from $.002 to $.008 to sterilize the surface of a 4x4x1-inch package. These estimates are calculated on the processing of 200 to 222 units per minute of packages containing liquid or powder that could be agitated during irradiation. The use of packaging materials that attenuate the X-rays would increase radiation costs.

HEAT TREATMENT OF TITANIUM ALLOYS

Because titanium as a major metal is relatively new, metallurgists have had little opportunity to study its alloys. Yet the usefulness of the metal depends to a great extent upon the building of alloys with adequate strength and ductility.

The investigations of Battelle metallurgists W. M. Parris, P. D. Frost, and J. H. Jackson indicate that titanium alloys which contain iron, chromium, manganese, molybdenum, and vanadium are most likely to provide the desired ductility and strength. Three of the most successful titanium alloys contain the following weight percentages of other elements: (1) chromium 3.5 and vanadium 3.5; (2) manganese 5.0 and chromium 2.5; and (3) chromium 1.0, iron 1.0, manganese 3.0, molybdenum 1.0, and vanadium 1.0. Tensile strengths up to 170,000 psi in sheet and to 195,000 psi in bar stock, with good ductility, were produced by cooling the metal at relatively fast rates from temperatures between 1300 and 1400 F.

Age hardening of solution-treated alloys at temperatures up to 700 F generally resulted in good strength but low ductility. On the other hand, overaging the alloys at 800 to 1100 F produced strengths of from 140,000 to 200,000 psi with corresponding elongations of 30 to 10 per cent in one inch. The properties of two of the three alloys, heat treated to 214,000 psi ultimate strength, were essentially unchanged after 1000 hours at 500 F. The third alloy, heat treated to 214,000 psi ultimate strength, was stable up to at least 500 hours at 500 F. This alloy, listed third above, is being distributed by the Air Force to a number of industrial organizations for evaluation as an aircraft structural material.

BRONZE COATINGS AND FINISHINGS

For years, scarce nickel has been the chief element for protecting metal surfaces subject to corrosive attack. Nickel has also been important as a base for chromium plate where bright finishes are desired. Earlier efforts to find satisfactory alternative protective coatings and bright finishes were unsuccessful. Copper-tin alloy plates, though having some necessary properties, lacked smoothness of finish and attractiveness of appearance. Now, after six years of research, Battelle technologists have developed both bronze and speculum finishes that offer better protection against corrosion than copper plus nickel plates and a bright smooth surface, as well. These plates are already in commercial production.

The process for producing this new Lustralite plate involves the use of a soluble stannous pyrophosphate complex to supply the tin in the bath. The copper is present as a copper cyanide complex compound. The tin and copper concentrations are maintained with metal dissolved from alloy anodes. With the new bath, the copper-tin alloys are deposited faster than was previously possible. Smooth, bright-speculum

or bronze alloy can be deposited at a rate of 0.004 in. per hr., using a cathode current density of 45 amp. per sq. ft.

An alloy plate deposited in this bath and containing 7 to 15 per cent tin and the remainder copper may be used as a base for chromium plating, a bearing overlay, a stopoff against nitriding, or an undercoat for decorative plating. Bronze-alloy plate with 17 to 22 per cent tin, balance copper, is harder than the above plate and has superior leveling power. By depositing only 0.0001 inch of bright nickel over this bronze, a clear chromium may be plated in conventional baths. Chromium may also be deposited directly over the bronze after buffing.

A third type of plate-bright speculum is very hard. It is resistant to scratches and excellent for indoor use on such items as flatware, builder's hardware, and appliances where temperatures will not exceed 225 F. The plate is easy to buff to a mirror appearance. Its excellent tarnish resistance also makes speculum ideal for reflectors.

CHEMURGISTS' VIEW

Research is the answer to the problem of farm surpluses, according to the National Farm Chemurgic Council. This view is expressed in an article in the *Chemurgic Digest* by Henry T. McKnight, president of the Council, and K. Starr Chester, chief of agricultural research at Battelle and chairman of the Council's Research Committee.

They believe that research can take care of the problem of farm surpluses by: (1) finding new industrial uses for surplus commodities; (2) making possible the substitution of industrial and other new crops for crops that are now in surplus; and (3) developing profitable by-products from agricultural wastes, the sale of which will make it possible to market surplus commodities at competitive prices.

The writers point out that research has tremendously increased the productivity of industrial workers. It has doubled the productivity of farm workers in the last 25 years. Nevertheless, they recognize that still further advances are possible through more intense application of research to agricultural problems.

A NEW ALLOY FOR WIRE

A recently developed Signal Corps lightweight communications cable is re-enforced with a braid of stainless steel wire to give it necessary strength. To assure the best performance of the cable, the re-enforcing wire must be relatively nonmagnetic and have low electrical conductivity. Originally, only chromium-nickel stainless steels met these requirements. The Signal Corps, however, desired an alloy which would conserve scarce alloying elements, particularly nickel.

The Coles Signal Laboratory asked Battelle metallurgists to develop such an alloy. H. O. McIntire and George Manning of the Institute report that a satisfactory nickel-free alloy has been found. In its composition, manganese and copper can be substituted for the nickel and much of the chromium used in the original wire. The Battelle metallurgists point out that moderate corrosion resistance, good workability, and low magnetic permeability can be expected from alloys within the following percentage ranges: carbon 0.08 to 0.15; chromium 9.0 to 11.0; manganese 14.5 to 18.5; silicon 0.3 to 1.3; copper 1.8 to 2.2; and nitrogen 0.08 to 0.15.

NEW TECHNICAL DIRECTOR

A. C. Richardson, who has supervised mineral processing research at Battelle for 20 years, has been named a technical director. He will share with the other technical directors in the responsibility for guiding the technical quality of the Institute's research program.

The new director is known in the mining and metallurgical industries for the investigations he has directed in the fields of minerals beneficiation, coal preparation, and extractive metallurgy.

STUDY OF PORCELAIN ENAMEL SLIPS

One of the major problems in the use of porcelain enamel slips is to attain stable suspensions of desirable consistency of the mixtures of the ground glass and clays in water. Salts known to be present in the slips are largely soda, sodium fluoride, and boric oxide. In his reexamination of the data on the behavior of enamels, Burnham W. King has found that the best slips contain equal amounts of soda and boric oxide and at least a moderate amount of sodium fluoride.

His investigations suggest that the salts which tend to form—and their relative stabilities—may play an important part in the handling characteristics of enamel slips. King concluded that the good features of slips, containing the proper proportions of soda, boric oxide, and sodium fluoride were traceable to: moderate solubility that changes very slightly with temperature; moderate pH of about 10, probably well buffered; sodium fluoride, a relatively stable crystalline material, as a primary phase; and a secondary phase that crystallizes slowly with relatively little shrinkage.

These investigations were reported to the recent meeting of the American Ceramic Society, in a paper entitled "Some Properties of the System Na_2O-NaF-B_2O_3-H_2O."

RECENT PAPERS AND ARTICLES BY THE RESEARCH STAFF*

Some Effects of Minor Elements on the Characteristics of Plain-Carbon Steels. Francis W. Boulger. Bogota Conference, October 13 to November 5, 1952. No. 1/2.75, 1952. Published jointly by the Economic Commission for Latin America and the Technical Assistance Administration for the United Nations.

The Analysis of Wrought Aluminum Alloys for Hydrogen. C. B. Griffith and M. W. Mallett. *Analytical Chemistry*, July, 1953.

Instrumentation for Statistical Quality Control. W. Hecox and R. L. Merrill. *Tooling and Production*, October, 1953.

Influence of Hydrogen Sulfide on Flame Speed of Protane-Air Mixtures. Philip F. Kurz. *Industrial and Engineering Chemistry*, October, 1953.

Potentials of Soft X-Rays in Sterilization. R. F. Robinson and R. C. McMaster. *Cathode Press*, Vol X, No. 3, 1953.

*In most cases, reprints will be available from the Battelle Publications Office upon request.

A Word About Battelle Technical Review Abstracts

The abstracts that appear in the following pages are prepared from approximately 1000 American and foreign technical journals, as well as from books and other literature received in the Battelle Library. Prepared by a professional staff trained in various technological fields, the abstracts are selected for their usefulness to the Battelle research staff. They are now being made available to technologists and scientists in industry and research in all parts of the world, through the pages of the *Battelle Technical Review*.

PRESSURE COOKER FOR ORES

The autoclave shown here plays an important role in research on hydrometallurgical processes. Working on the principle of the pressure cooker, but with much higher pressures and temperatures, it increases the effectiveness of many hydrometallurgical processes where gases or liquids are reacting with ores. The autoclave may be used for leaching out the valuable material from ores, converting the economic material in ores to soluble compounds, and the direct oxidation or reduction of metals in solution.

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BATTELLE INSTITUTE was founded by the will of Gordon Battelle as a memorial to the Battelle family. The Battelles were among the first settlers of Ohio and were prominent in the development of the state's iron and steel industry.

Gordon Battelle, last of the family line, was impressed with the benefits to be derived from industrial research and left his estate for the building and endowment of an Institute "for the purpose of education . . . the encouragement of research . . . and the making of discoveries and inventions for industry." The Institute began operations in 1929.

As established, Battelle provides, on a not-for-profit basis, the physical plant, equipment, and personnel for conducting research. The great bulk of it is applied research conducted for industry and government.

In keeping with its educational function, the Institute also conducts fundamental or basic research. The results of much of this research are published for the general encouragement of science and industry, and to benefit the public welfare.

Fields of research at Battelle include agriculture and practically all the industrial and engineering sciences.